

# ManTech

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**ManTech SRS Technologies, Inc.**

*Progress of Deformable  
Membrane Mirror to Correct  
Large Amplitude Aberrations*

Presented by Brian Patrick, MSRS

Technology Days 2008



Secure Systems  
and Infrastructure  
Solutions



Information  
Technology  
Solutions

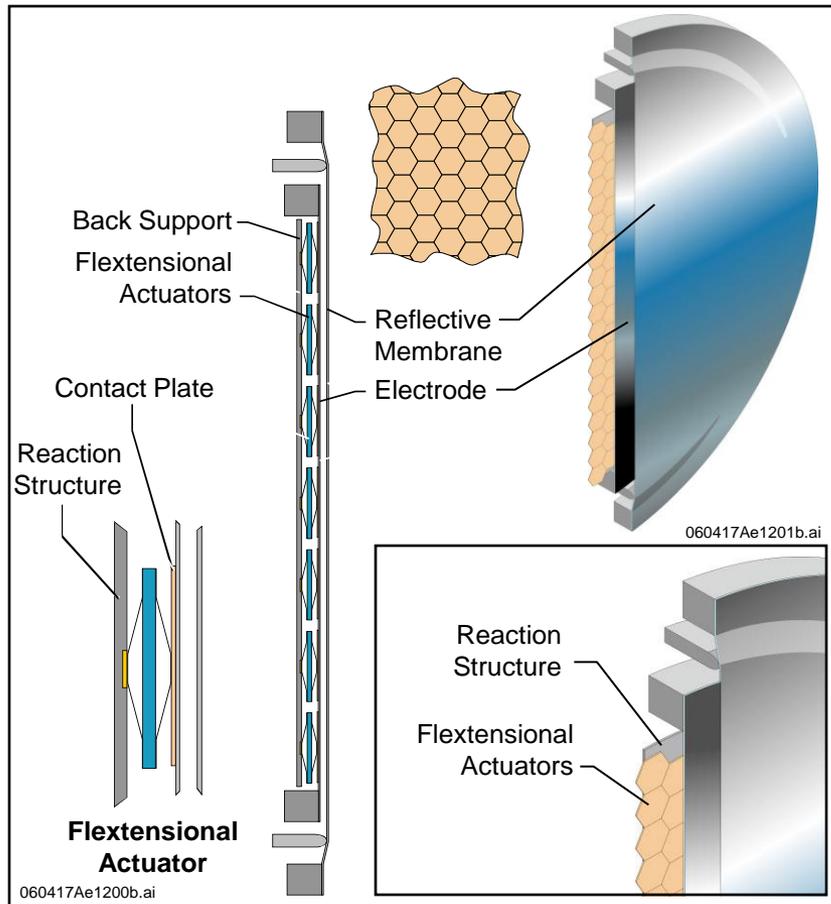


Systems  
Engineering  
Solutions

- Membrane Mirror with Flextensional Actuators Concept
- Initial Deformable Mirror Modeling
  - Actuator layout optimization, capability prediction
- Multiple Electrode Configurations/Test Results
- Near Term Activities



## Hybrid DMM Concept



Combines TRS Technologies' flextensional actuators with MSRS Technologies' Membrane Mirror Technology

## Significance:

- Correction for low order aberrations with large magnitude
- Large aperture capable
- Light weight
- Broad temperature range
- Low voltage

## Approach:

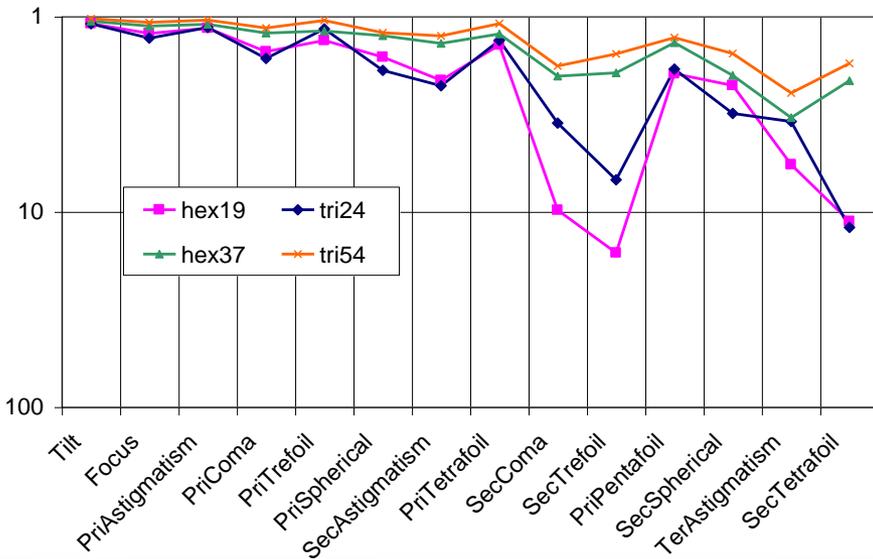
Conduct FEM to optimize the shape control and performance of a 0.25 m mirror with various configurations. Parameters include electrode positioning, stress state, mechanical properties of material, mounting positions, driving conditions, etc.

- Modeled new design case with 54 triangular electrodes (Case 6 – Tri54)
- Used model to create influence functions for correctability analysis
- Tri54 case performs better than other three geometries due to greater number of electrodes

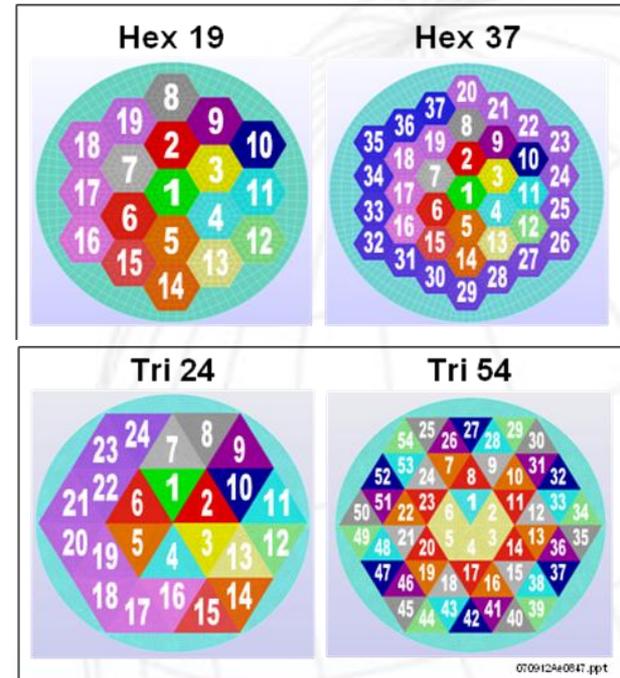
| Case     | Electrode Geometry | Electrode Number | Film Stress (psi) | Pressure Load on Actuated Electrode ‡ |
|----------|--------------------|------------------|-------------------|---------------------------------------|
| 1        | Hexagonal          | 19               | 2580              | 1x                                    |
| 2        | Triangular         | 24               | 2580              | 1x                                    |
| 3        | Hexagonal          | 19               | 1000              | 1x                                    |
| 4        | Hexagonal          | 19               | 2580              | 7x                                    |
| 5        | Hexagonal          | 37               | 2580              | 1x                                    |
| <b>6</b> | <b>Triangular</b>  | <b>54</b>        | <b>2580</b>       | <b>1x</b>                             |

‡ 1x Load = 0.052psi, 7x Load = 0.104psi

Design Correctability Study

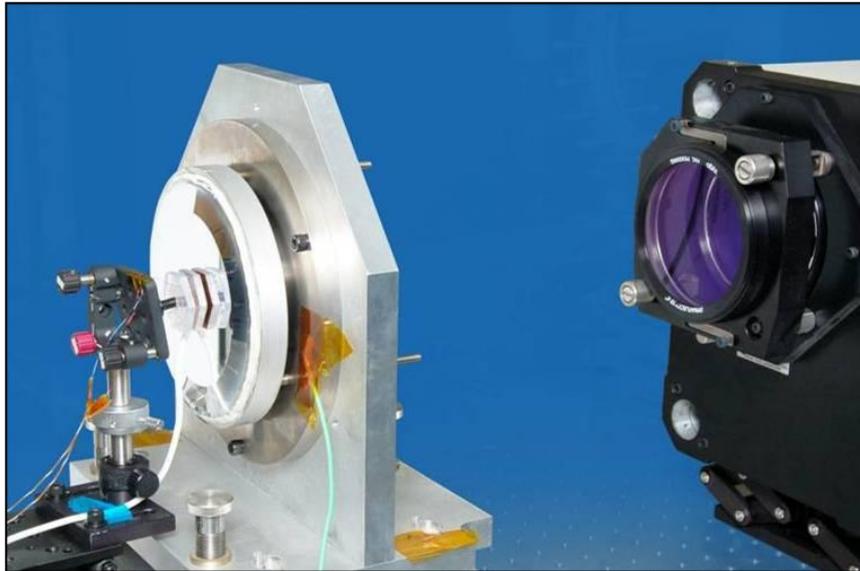


Models created to-date



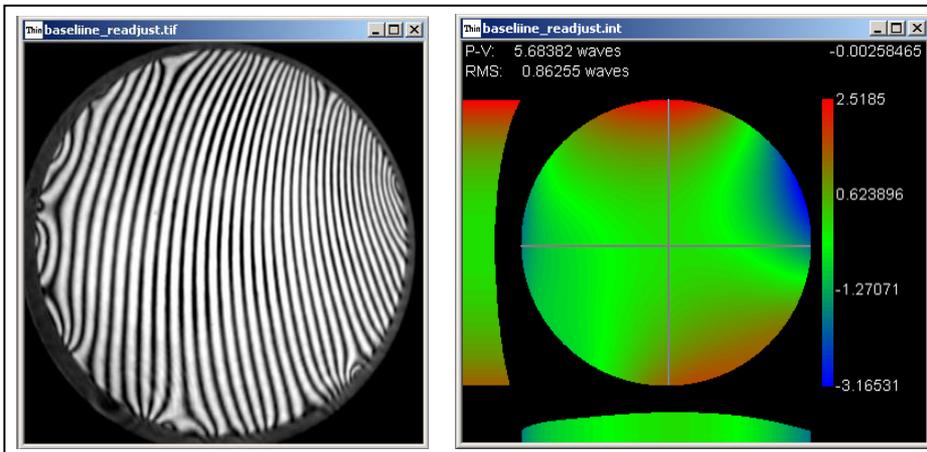
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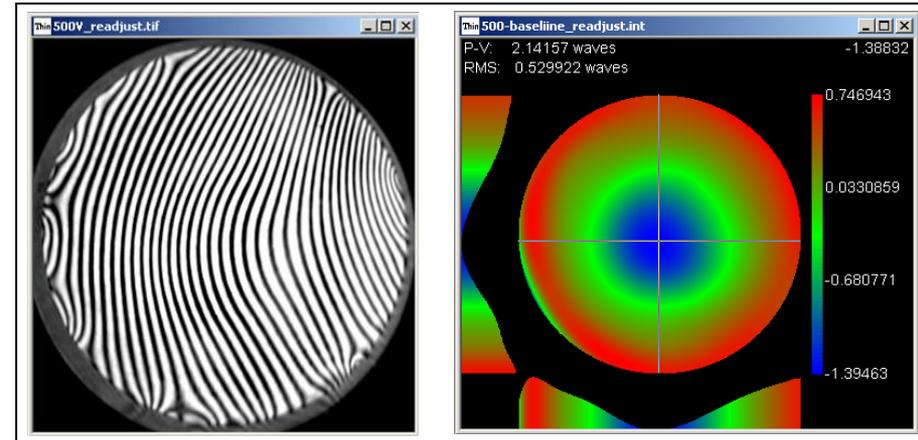


- Initial test setup using 10cm diameter CP1 and Novastrat membrane mirror complete
- Test data will be used for FEM correlation
- Initial data taken for single hexagonal electrode with one TRS flextensional actuator

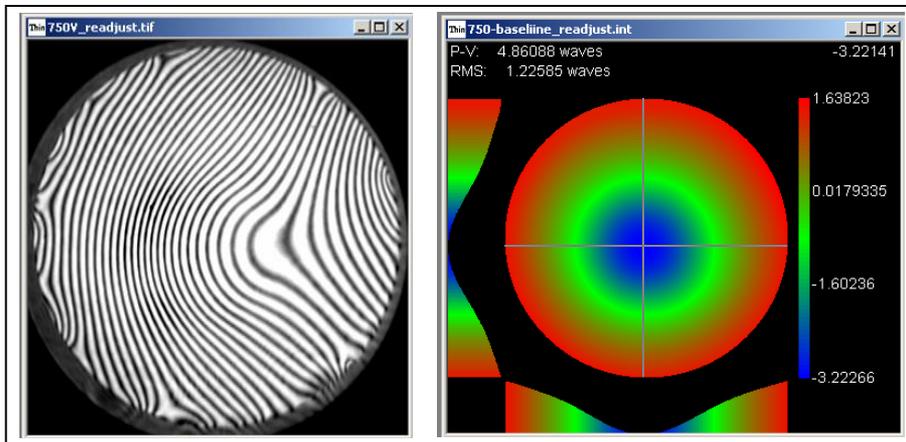




Interferogram and corresponding OPD plot for membrane mirror with no electrostatic voltage.



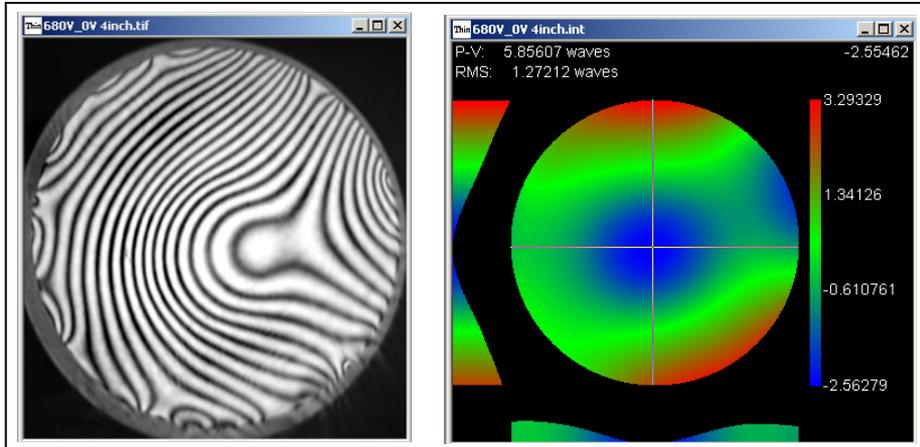
Interferogram and OPD plot with electrostatic voltage set at 500V (note, OPD plot has the baseline subtracted out).



Interferogram and OPD plot with electrostatic voltage set at 750V (OPD plot has the baseline subtracted out).

- Initial Electrode Test - 0V to flextensional actuator
- 1.65mm electrode distance from membrane mirror
- Hexagonal shape with 1.91cm long sides

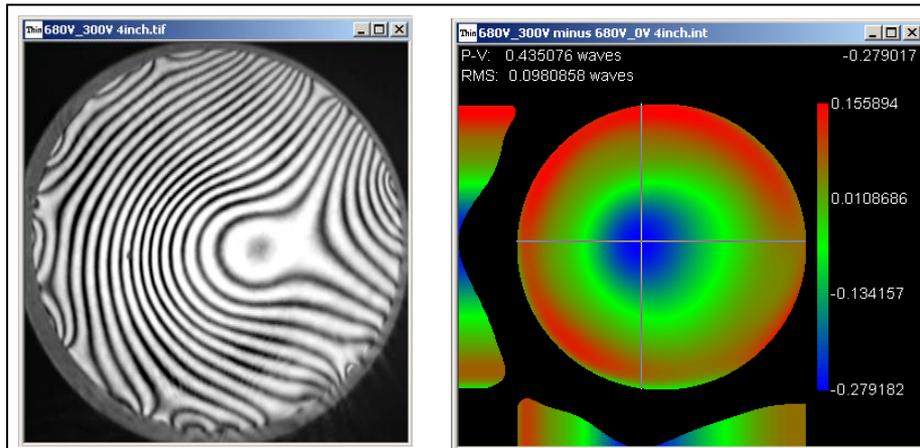




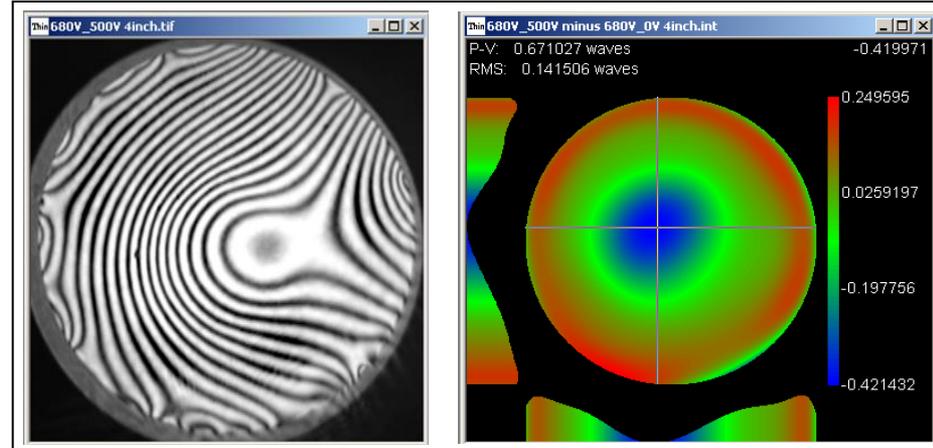
Interferogram and corresponding OPD plot for membrane mirror with electrostatic voltage set at 680V and flextensional set to 0V

- Initial Electrode and Flextensional Test
  - 680V applied to electrode and 300V and 500V to flextensional
- 300V resulted in 0.18 microns max displacement.
- 500V resulted in 0.27 microns max displacement.
- Primarily focus

(Data for actuator displacement has baseline subtracted from it to show influence function)



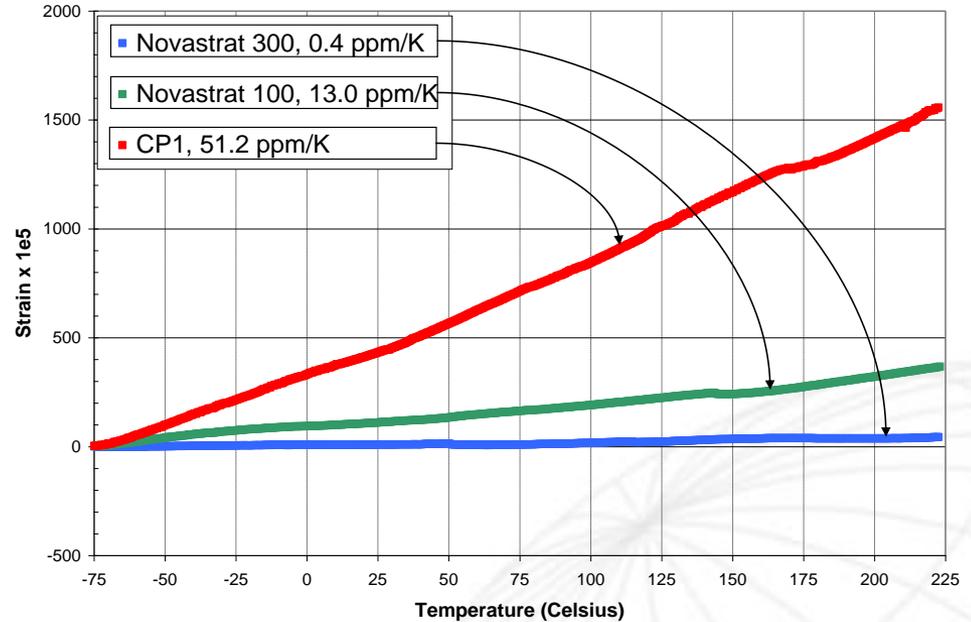
Interferogram and corresponding influence function for electrostatic voltage set at 680V and flextensional set to 300V



Interferogram and corresponding OPD plot for membrane mirror with electrostatic voltage set at 680V and flextensional set to 500V.

## Novastrat History and Overview

- The Novastrat series is a polymer family with controlled CTE.
- Novastrat was designed for interlayer dielectrics, and exhibit good adhesion to silicon substrates.
- All Novastrats are high temperature polyimide materials.
- Novastrat 300 was designed to exhibit near-zero CTE at mils thickness.
- Currently fabricated in 2' x 2' panels.
- Readily scalable to 6' x 6' panels or larger.



| Property*                    | Novastrat 300 | Novastrat 100 | Kapton HN | CP1           |
|------------------------------|---------------|---------------|-----------|---------------|
| In Plane CTE (ppm/°C)        | 0.4           | 13.0          | 20.0      | 51.2          |
| Tg (°C)                      | >300          | >300          | >300      | 263           |
| Tensile Strength (ksi)       | 23.8          | 30.1          | 33.5      | 14.5          |
| Tensile Strength (MPa)       | 164           | 208           | 231       | 100           |
| Youngs Modulus (ksi)         | 600           | 880           | 370       | 315           |
| Youngs Modulus (GPa)         | 4.1           | 6.0           | 2.6       | 2.2           |
| Solvent Resistance           | Excellent     | Excellent     | Excellent | Poor          |
| Color                        | Yellow        | Yellow        | Orange    | Slight Yellow |
| Dielectric Constant (10 GHz) | 3.1**         | 3.0**         | 3.4       | 2.5           |

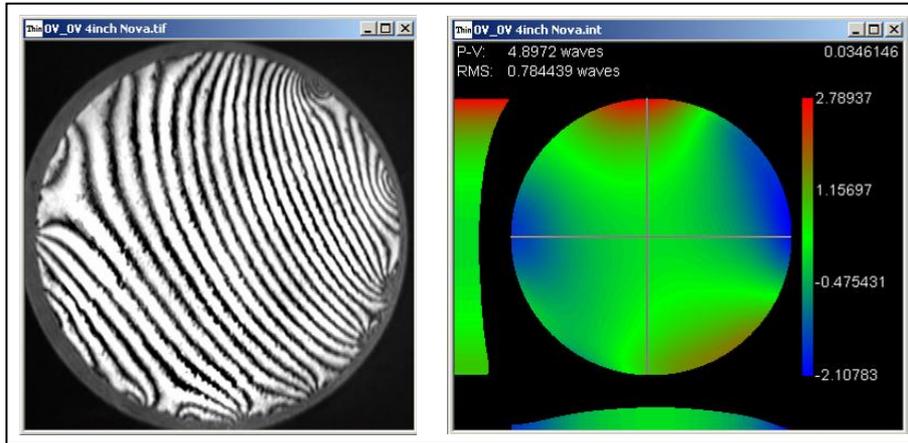
\* All properties measured at 23 °C

\*\* Estimates from circuitry tests.

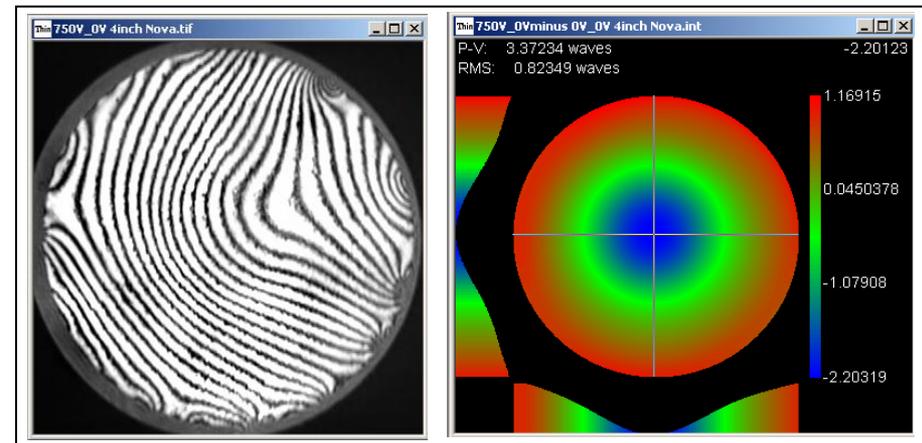
**SRS**  
TECHNOLOGIES

2 mil Novastrat 300 Zero CTE Polyimide

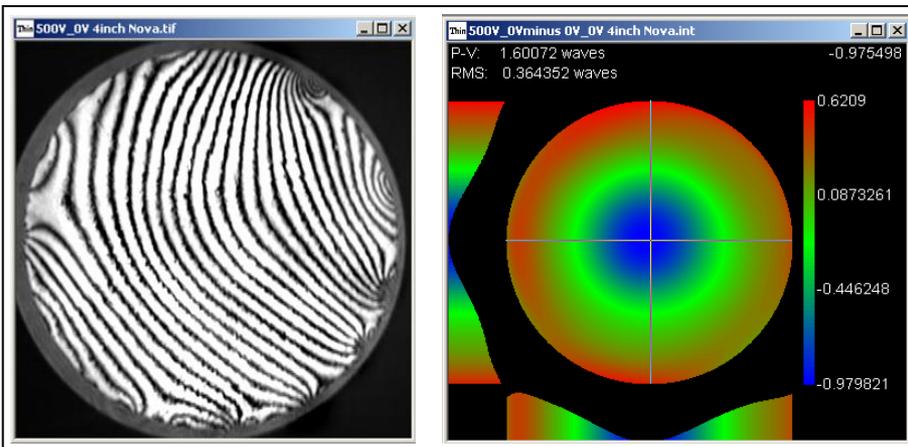




Interferogram and corresponding OPD plot for Novastrat membrane mirror with no electrostatic voltage.



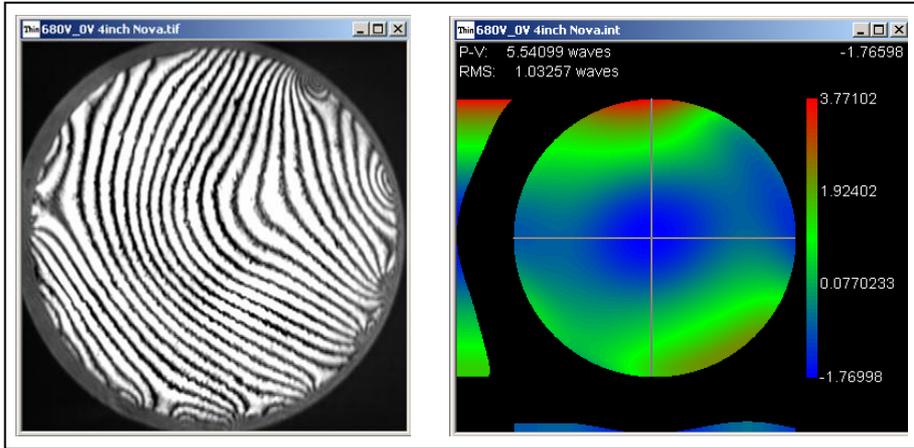
Interferogram and OPD plot with electrostatic voltage set at 750V for Novastrat membrane (OPD plot has the baseline subtracted out).



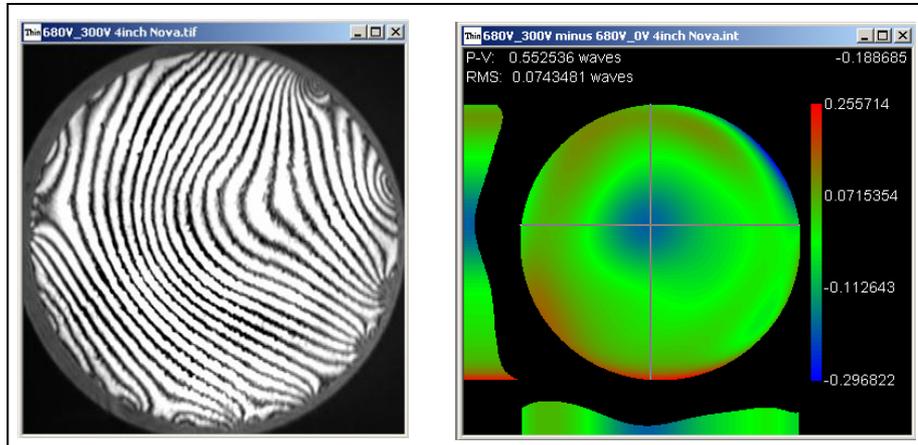
Interferogram and OPD plot with electrostatic voltage set at 500V for Novastrat membrane (note, OPD plot has the baseline subtracted out).

- Initial Electrode Test / 0V to flextensional
- 1.65mm electrode distance from membrane mirror
- Hexagonal shape with 1.91cm long sides



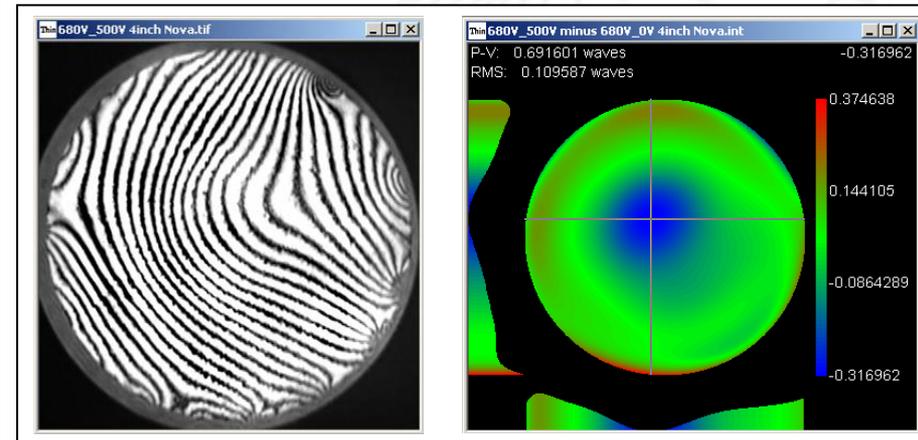


Interferogram and corresponding OPD plot for Novastrat membrane mirror with electrostatic voltage set at 680V and flextensional set to 0V.



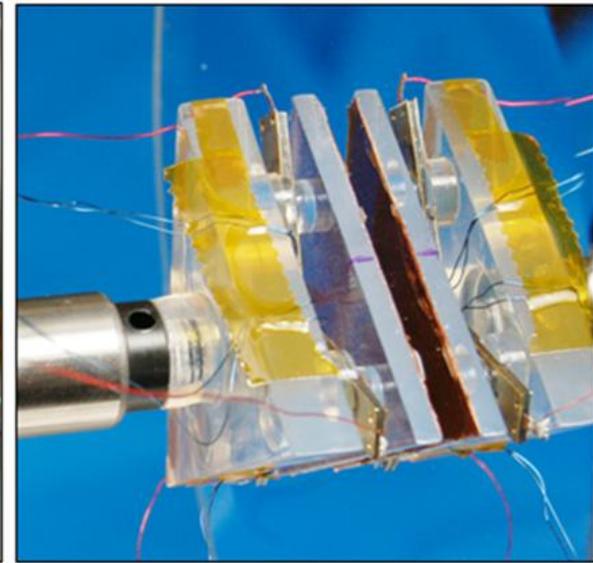
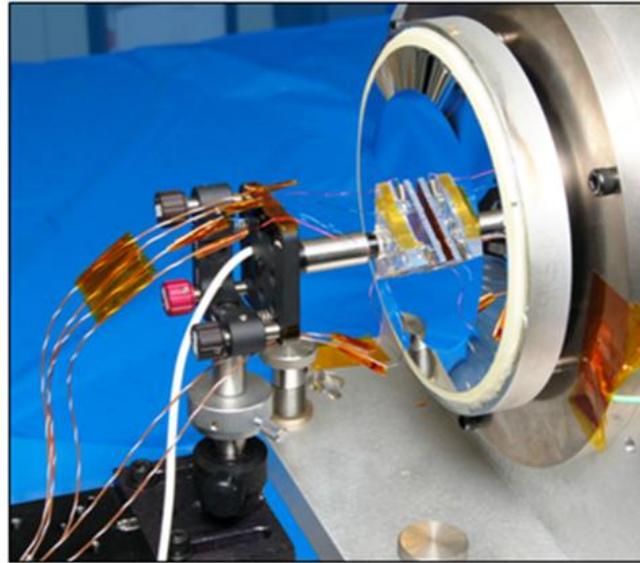
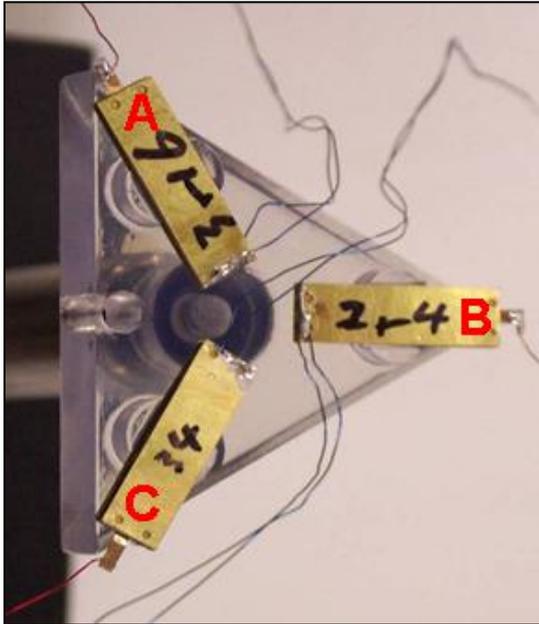
Interferogram and corresponding influence function for electrostatic voltage set at 680V and flextensional set to 300V.

- Initial Electrode and Flextensional Test
  - 680V applied to electrode and 300V and 500V to flextensional
- 300V resulted in 0.12 microns max displacement.
- 500V resulted in 0.20 microns max displacement.
- Primarily focus  
(Data for actuator displacement has baseline subtracted from it to show influence function)



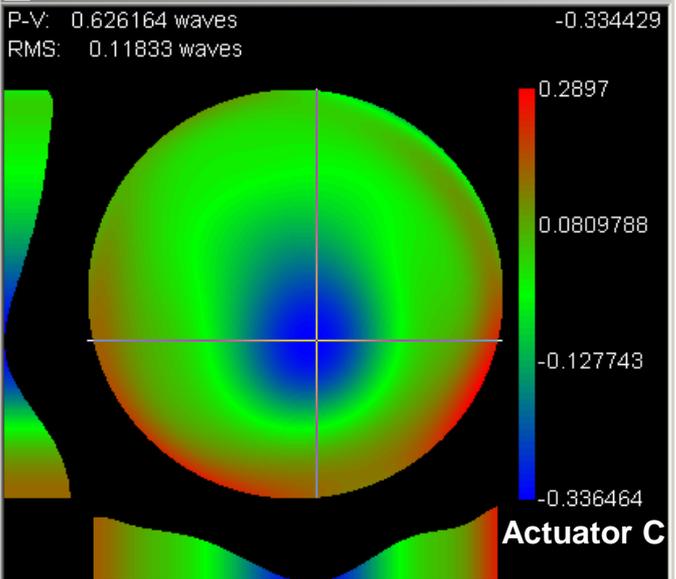
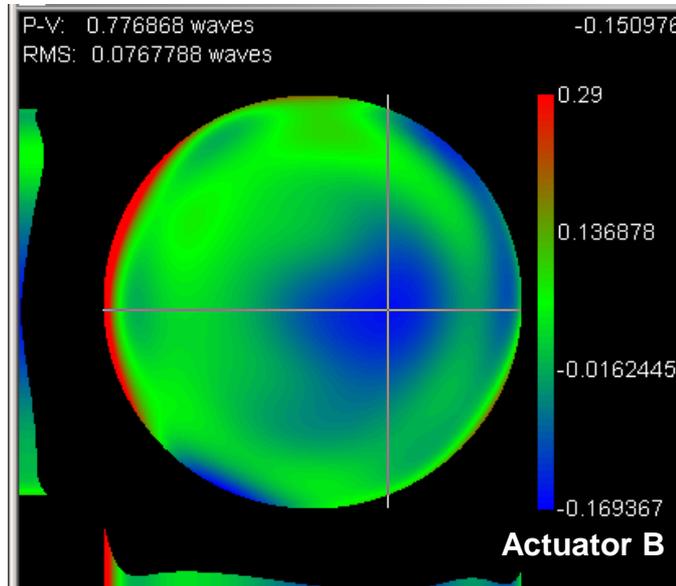
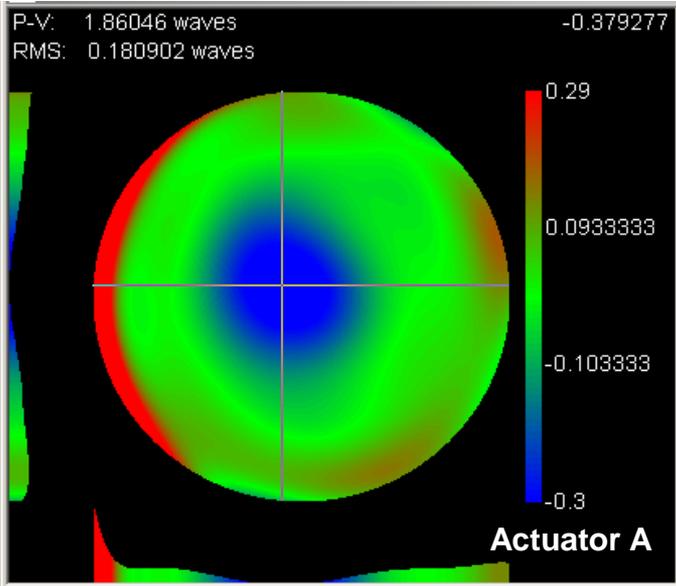
Interferogram and corresponding OPD plot for Novastrat membrane mirror with electrostatic voltage set at 680V and flextensional set to 500V.





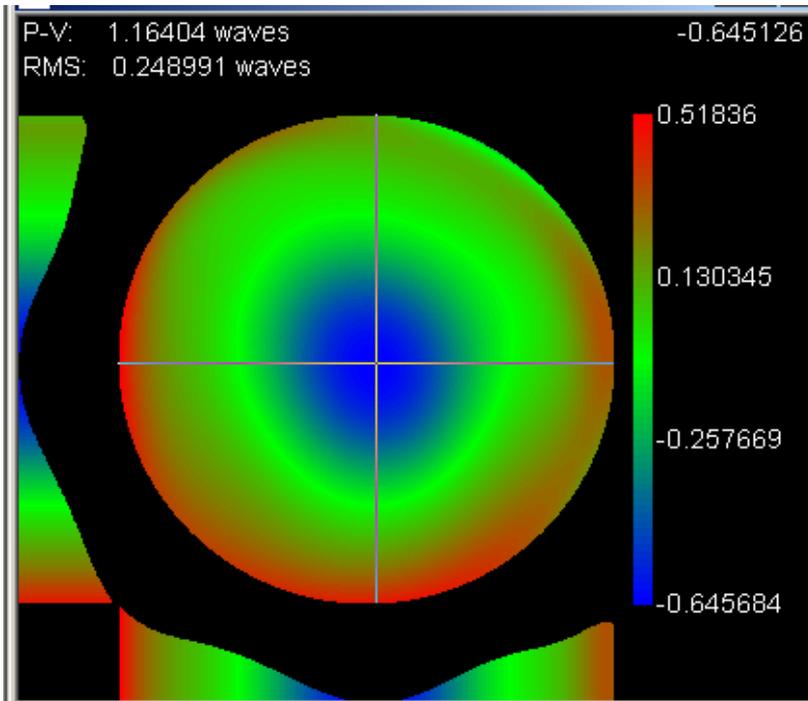
- Testing at MSRS of 3-flextensional single electrode.
- Test conducted using TRS Flextensional Actuators.
- Same membrane mirror setup used from Hex electrode test.





- OPD plots for flextensional actuator influence functions.
  - Each plot shows a single actuator energized to 300V with the electrostatic charge set to 700V
- Variances in depth for each actuator can be attributed to slight non planarity between electrode surface and mirror.





- **OPD plot shown for all actuators set at 300V and electrostatic charge still at 700V.**
- **Again, slight non planarity between electrode surface and mirror is cause for slightly skewed influence function.**

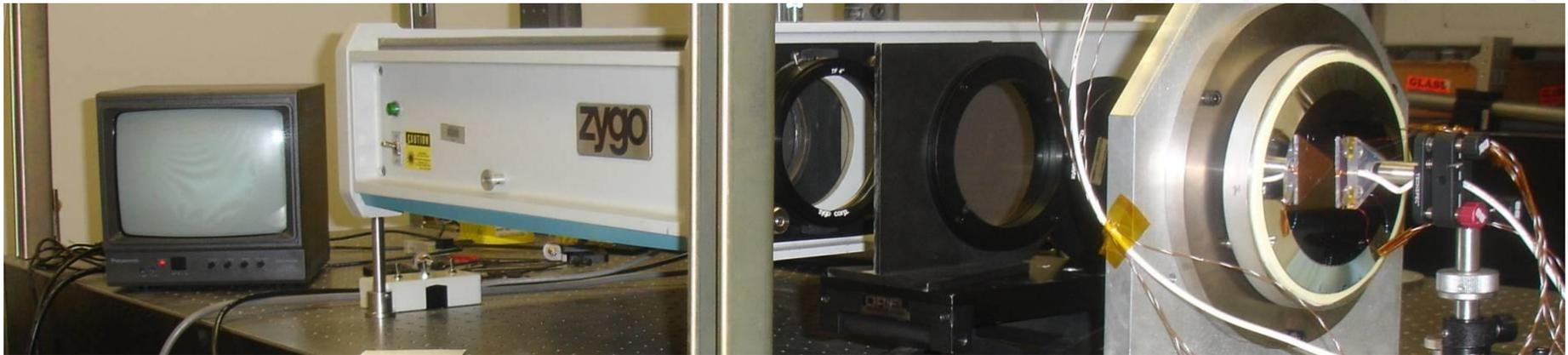


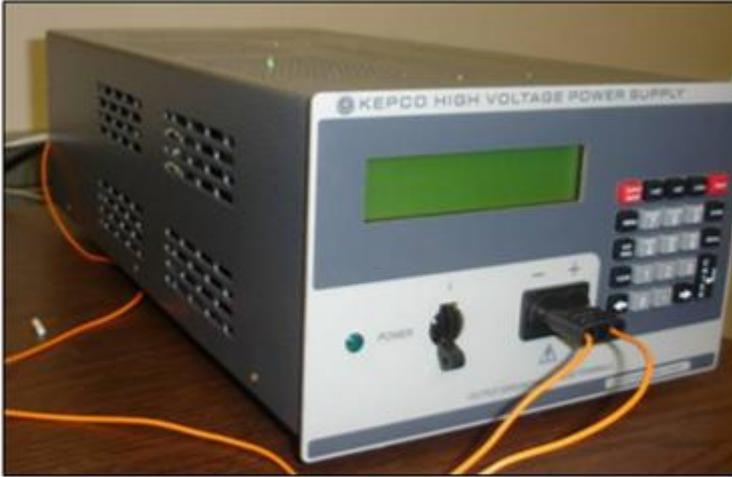
## Single Cell Deformable Membrane

- 3 Actuators
- Triangular Plate
- Membrane
- Controlled with custom driver

## Zygo Interferometer

- Metrology to test surface deformation of membrane
- Current wavefront sensor in order to analyze information across entire surface during testing
- MetroScript code written to control

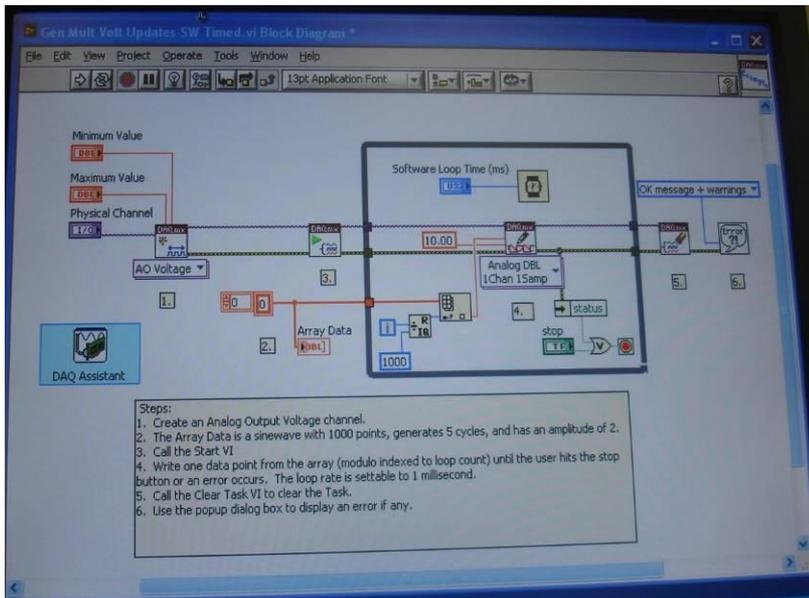




- **Kepeco Power Supply**
  - 0 to 500V
  - Capable of control via Labview, updates to software necessary
- **NI MUX**
  - 6x 12ch boards
  - Labview code written to switch power supply voltage to various actuators

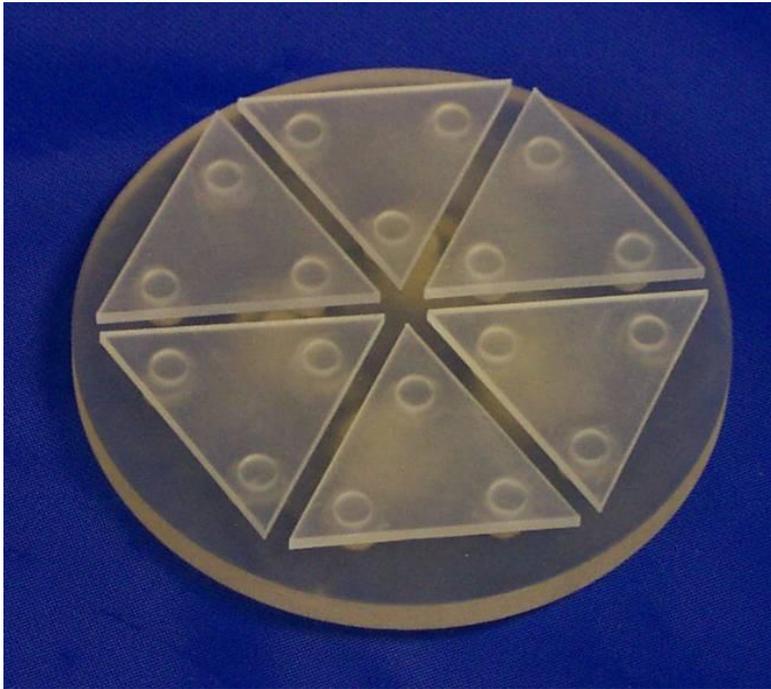


- Influence Functions
  - Code written to apply voltage to individual actuators
  - Surface deformation recorded



- Reconstructor
  - Least Square Fit, currently set up for testing purposes
  - Weighting components of RC, with specific application
- Correctability
  - Close loop
  - Create Zernike aberrations
  - Flatten membrane





- **Six Electrode – Tri Actuator testing**
- **Algorithm development for control system mirror shape correction.**
- **Finalize actuator layout design for deliverable test article**
- **Test article mount design and fabrication**

